EXPLOITING FLY ASH IN MINIMIZING HERBICIDE TRANSPORT IN AGRICULTURAL SOILS

Implemented by

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For

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EXECUTIVE SUMMARY

Presence of pesticides in ground water resources has increased in the past few years which have become an intensive environmental problem and burning issue of discussion. Soil amendments can play a vital role in the management of run off and leaching of pesticides due to changes in physico-chemical properties of soil affecting sorption, transport and degradation of the soil-applied pesticides.

In the present work effect of fly ash from different sources was studied on sorption, degradation and leaching of two highly mobile herbicides metribuzin and metsulfuron-methyl. Soils were amended with fly ash at 0, 0.5, 1, 2 and 5% (w/w basis). Sorption studies were performed using batch method at 1:2 soil/soil+fly ash: solution (w/v) ratio. Degradation studies were performed under nonflooded (60% water holding capacity) and flooded conditions. Leaching studies were performed in packed soil columns [30 cm (l) x 5.9 cm (d)]. Fly ash at required levels was thoroughly mixed in the top 15 cm soil of column and metribuzin (550 µg) or metsulfuron-methyl (100 µg) was applied at the column surface in acetone (0.1 ml). Columns were leached with 1000 ml of water which was equivalent to 320 mm rain fall. Field experiments were conducted using fly ash @ 40 t/ha in soybean and wheat crops as metribuzin and metsulfuron-methyl, respectively, are recommended herbicides in these crops.

During first year the effect of fly ashes from Kota and Inderprastha thermal power plants on sorption-desorption of metribuzin in three soils from different agro climatic conditions (IARI-New Delhi, Jhargram-WB and Almora-UA) was studied. Sorption desorption studies were carried out at 0, 0.5, 1, 2 and 5% fly ash amendment levels. The Inderprastha fly ash was very effective in increasing the metribuzin sorption and 15-92% increase in sorption was observed. Whereas, Kota fly ash showed marginal increase of 13-38% in metribuzin sorption. Both the fly ashes reduced metribuzin desorption, but, comparatively, Inderprastha fly ash (64-91%) was more effective than the Kota fly ash (33-71%). Metribuzin sorption in the Inderprastha fly ash-amended soils showed good correlation with the fly ash content and sorption increased with increasing dose of fly ash.

Persistence of metribuzin in Kota and Inderprastha fly ash (0, 1, 2 and 5%) amended flooded and nonflooded soils was studied. Metribuzin was more persistent in the flooded soils than the nonflooded soils. Kota fly ash amendment to nonflooded soils slightly increased the metribuzin persistence while Inderprastha fly ash decreased metribuzin persistence. Both the fly ash enhanced metribuzin dissipation in flooded soils and Inderprastha fly ash was more effective than Kota fly ash. The effect of fly ash amendment on half life values was dose dependent and it increased with increasing level of fly ash amendment. Fly ash amendment to flooded soils had more pronounced effect on metribuzin dissipation than the nonflooded soil systems.
Not all types of fly ashes were found to have the same effect on metribuzin sorption and degradation. Thus, seven fly ashes from different sources viz: Kota, Rajasthan; Inderprastha and Badarpur, Delhi; Dadri and Kasimpur, Uttar Pradesh; Panipat, Haryana, and Neyveli, Tamil Nadu were evaluated for metribuzin sorption. These were found to have varying capacity to adsorb metribuzin from 55 to 99.5%. Fly ashes can be used as soil amendment for increasing herbicide sorption and reduced leaching. However, since each type of fly ash has variable physico-chemical properties, particle size distribution, etc, degree of sorption of pesticide is variable. Inderprastha fly ash exhibited maximum sorption (99.9%) of metribuzin followed by the Badarpur and Neyveli fly ash (~92%). Least metribuzin sorption was observed in the Kota fly ash (55%). Correlating the sorption of metribuzin with physico-chemical properties of fly ash showed that metribuzin sorption was negatively correlated with cation exchange capacity (r-0.667) and positive correlation was observed with organic carbon (r-0.590) content and surface area (r-0.557) of the fly ash. But, when fly ash was amended to soils, then OC content of the soil did not correlate with the metribuzin sorption as Koc (sorption normalized to organic carbon content) values for metribuzin in all the soils showed wide variation.

Leaching of metribuzin was studied in 0, 1, 2 and 5% Inderprastha fly ash amended IARI, Jhargram and Almora soils. Mixing fly ash in upper half (15 cm) of the column reduced metribuzin leaching losses. In 2% fly ash amended columns the metribuzin leaching losses were reduced by 65, 49 and 42% in IARI, Jhargram and Almora soils, respectively. However, in 5% fly ash amended columns no metribuzin was recovered in the leachate even after percolating water equivalent to 362 mm rainfall. Fly ash application resulted in greater retention of metribuzin in the application zone and better effect was observed in the organic carbon poor IARI and Jhargram soils.

Effect of Inderprastha fly ash amendment on metribuzin bioactivity in IARI soil was studied by Chenopodium album seed germination method. Fly ash at 2 and 5% level had no adverse effect on metribuzin bioactivity with 37.5, 32.5 and 35% seed germination in control (no fly ash), 2 and 5% fly ash amended soils, respectively.

Sorption of metsulfuron-methyl was also studied in Inderprastha fly ash 0.5, 1, 2, 5%) amended IARI, Jhargram and Almora soils. There was significantly higher sorption of metsulfuron-methyl in fly ash amended soils, especially at 1-5% level. Maximum increase in metsulfuron-methyl sorption was observed in Jhargram soil where even at 0.5% fly ash amendment level 100% sorption was observed, while in IARI and Almora soils 100% sorption of metsulfuron-methyl was observed at 2% fly ash level. Compared to nearly 50% desorption of sorbed metsulfuron-methyl from control soils <10% of the sorbed metsulfuron-methyl was desorbed from 1% fly ash amended soils.
Leaching of metsulfuron-methyl was studied in 1, 2 and 5% Inderprastha fly ash amended IARI and Jhargram soils. Fly ash reduced the leaching losses of metsulfuronmethyl in IARI soil columns and compared to control (no fly ash) 1 and 2% fly ash amendment reduced the metsulfuron-methyl leaching losses by 20 and 97%, respectively. No metsulfuron-methyl leaching was observed in 5% fly ash amended IARI soil column. In Jhargram soil column, where after 1% fly ash amendment metsulfuron-methyl leaching was reduced by 89%, no herbicide leaching was observed in 2 and 5% fly ash amended columns. Fly ash amendment to soils resulted in maximum retention of herbicide in 0-10 cm soil layer.

Persistence of metsulfuron-methyl in Inderprastha fly ash (1, 2, 5%) amended IARI and Jhargram soils was studied under nonflooded and flooded conditions. Fly ash increased the rate of metsulfuron-methyl dissipation in both the soils under nonflooded and flooded conditions and nearly 50% faster metsulfuron-methyl dissipation was observed in 5% fly ash amended soils.

Effect of Inderprastha and Badarpur fly ash (1, 2 and 5%) amendment was studied on microbial biomass carbon content, soil dehydrogenase and fluorescein diacetate (FDA) activity in IARI and Jhargram soils. Dehydrogenase activity was inhibited with increasing dose of fly ash and Inderprastha fly ash showed more inhibition. There was no effect of fly ash on the FDA activity while microbial biomass carbon content was slightly enhanced in Inderprastha fly ash amended IARI soil.

Adsorption-desorption, degradation, leaching and bioactivity studies of metribuzin and metsulfuron-methyl suggested that at highest (5%) application dose of fly ash, herbicides, especially metsulfuron-methyl, were completely adsorbed in the soil and dissipated at faster rate. This situation can result in less availability of herbicides for weed control and herbicides will not be effective for longer duration. Therefore, 2% fly ash application appeared to be optimum for effective weed control and reduced herbicide leaching.

Field evaluation of Inderprastha and Badarpur fly ash amendment on persistence of metribuzin, its downward mobility and bioactivity was studied in soybean cropping system in 2x2m plots. Fly ash was applied at the rate of 40 t/ha while metribuzin was applied at the recommended rate of 0.5 kg/ha as pre-emergent herbicide. Under field conditions, metribuzin persisted till 40 days in soil without fly ash amendment and for 112 days in fly ash amended soil. Herbicide dissipation in fly ash amended plots was found to be biphasic, probably soil bound metribuzin was not easily available for degradation. In first phase the rate of dissipation was faster (half-life = 4.4-4.5 days) while it slowed down in the second phase (half-life = 43-48.5 days). In control soil the half life of metribuzin dissipation was found to be 4.2 days. No metribuzin was recovered from the 15-30 cm soil profile in fly ash amended plots while traces (0.6-1.2 µg/kg) of metribuzin were recovered from 15-30 cm soil profile of control plots. In control
plots lesser amounts of two metribuzin metabolites (Deaminometribuzin and Diketodeaminometribuzin) were retained in the surface soil (0-15 cm profile) as compared to fly ash amended plots. Lower amounts of both the metabolites were recovered from the 15-30 cm profile of fly ash treated plots than the amount recovered from control plots. These findings suggested that fly ash amendment to soil resulted in greater retention of metribuzin and its metabolites in the upper soil profile. Fly ash amendment had no effect on the bioactivity of metribuzin (weed control efficacy) and yield of soybean.

Similarly, effect of Inderprastha and Badarpur fly ash amendment on metsulfuron-methyl persistence, its downward mobility and bioactivity was studied in wheat cropping system. Fly ash was applied at the rate of 40 t/ha while metsulfuronmethyl was applied at the recommended dose of 8g/ha as post emergent herbicide. Metsulfuron-methyl persisted till 15 days in control field and herbicide concentration reached below detectable limits on 20th day. However, metsulfuron-methyl was detected in fly ash amended field soils on 20th day and its concentration reached below detectable limits on 30th day. No metsulfuron-methyl was recovered from the 15-30 cm soil profile in any of the treatment. Half life of metsulfuron-methyl in control field soil was 4.1 days. Fly ash amendment slightly increased metsulfuron-methyl half life (t1/2 was 6.9 and 6.7 days in Inderprastha and Badarpur fly ash amended plots, respectively). No metabolites of metsulfuron-methyl were detected in soils. Fly ash amendment had no adverse effect on metsulfuron-methyl bioactivity. Compared to 89.9% weed control in control plot the weed control in Inderprastha and Badarpur fly ash amended plots was 95.7 and 96.4%, respectively. Slightly higher crop yields were obtained in Inderprastha fly ash amended plot.